be entered without requiring that the figures be classified as new matter (please see Explanation).

Please allow element number 155 (gap between corner bend 12 and slit 108) to be added to FIG.21A.

Please allow element number 161 (corresponding angle) to be added to FIG. 21.

Please allow FIG. 3 (which included detail enlargements A and B) to become FIGs. 3, 3A, and 3B.

The new drawings include the requested corrections and additions which are indicated in red in the attached pages of drawings. If these changes are not found to be acceptable, Applicant will supply new formal drawings upon request of the Examiner.

IN THE SPECIFICATION

Please amend the specification as follows. The marked-up pages are also enclosed herein.

Please amend the section 'Cross-Reference to Related Applications' on page 1, line 3 to read as follows:

This application is a continuation application of copending non-provisional application Serial No. 09/777,091, filed February 5, 2001.

Please amend the paragraph beginning on page 1, line 10 as follows:

As minimally invasive techniques and instruments for placement of intraluminal devices have developed over recent years, the number and types of treatment devices have proliferated as well. Stents, stent grafts, occlusion devices, artificial valves, shunts, etc., have provided successful treatment for a number of conditions that heretofore required surgery or lacked an adequate solution altogether. Minimally invasive intravascular devices especially have become popular with the introduction of coronary stents to the U.S. market in the

early 1990s. Coronary and peripheral stents have been proven to provide a superior means of maintaining vessel patency. In addition, they have subsequently been used as filters and as occluders, or in conjunction with grafts as a repair for abdominal aortic aneurysm, with fibers or other materials as occlusion devices, and as an intraluminal support for artificial valves, among other uses.

Please amend the paragraph beginning on page 2, line 17 as follows:

There exists a need to have a basic stent, including a fabric or biomaterial covering, that is capable of being delivered with a low profile, while still having a sufficient expansion ratio to permit implantation in larger vessels, if desired, while being stable, self-centering, and capable of conforming to the shape of the vessel. There is a further need to have an intraluminal valve that can be deployed in vessels to replace or augment incompetent native valves, such as in the lower extremity venous system to treat patients with venous valve insufficiency. Such a valve should closely simulate the normal functioning valve and be capable of permanent implantation with excellent biocompatibility.

Please amend the paragraph beginning on page 3, line 11 as follows:

In one aspect of the invention, the covering comprises a plurality of leaflets, each leaflet having a body extending from a wall-engaging outer edge to a free edge which is cooperable with one or more opposing leaflets to prevent flow in one direction, such as retrograde flow, while at least a portion of the leaflets have sufficient flexibility, when *in situ* to move apart, thereby creating a valve orifice that permits flow in the opposite direction, such as normal blood flow. The outer edge of each leaflet is adapted to engage and resiliently exert force against a wall of the bodily passage such that it extends in both longitudinal and circumferential directions along the vessel wall to at least partially seal a portion of the vessel lumen, while the free edge of each leaflet traverses the passageway across the diameter of the vessel.

Please amend the paragraph beginning on page 3, line 23 as follows:

In another aspect of the invention, the valve includes a frame that is covered by a piece of biocompatible material, preferably an Extracellular Collagen Matrix (ECM) such as small intestinal submucosa (SIS) or another type of submucosal-derived tissue. Other potential biomaterials include allografts such as harvested native valve tissue. The material is slit or otherwise provided with an opening along one axis to form two triangular valve leaflets over a four-sided frame. In the deployed configuration, the leaflets are forced open by normal blood flow and subsequently close together in the presence of backflow to help eliminate reflux. Other configurations include a two-leaflet valve having an oval or elliptically shaped frame, and valves having three or more legs and associated leaflets, which provide a better distribution of the load exerted by the column of fluid acting on the leaflets.

Please amend the paragraph beginning on page 5, line 1 as follows:

In still another aspect of the present invention, the device includes a frame that in one embodiment, is formed from a single piece of wire or other material having a plurality of sides and interconnecting bends. The bends can be coils, fillets, or other configurations to reduce stress and improve fatigue properties. The single piece of wire is preferably joined by an attachment mechanism, such as a piece of cannula and solder, to form a closed circumference frame. The device has a first configuration wherein the sides and bends generally lie within a single, flat plane. In an embodiment having four equal sides, the frame is folded into a second configuration where diagonally opposite bends are brought in closer proximity to one another toward one end of the device, while the other opposite ends are folded in closer proximity together toward the opposite end of the device. In the second configuration, the device becomes a self-expanding stent. In a third configuration, the device is compressed into a delivery device, such as a catheter, such that the sides are generally beside one another. While the preferred embodiment is four-sided, other polygonal shapes can be used as

well. The frame can either be formed into a generally flat configuration, or into the serpentine configuration for deployment. Besides rounded wire, the frame can comprise wires of other cross-sectional shapes (e.g., oval, delta, D-shape), or flat wire. Additionally, the frame can be molded from a polymer or composite material, or formed from a bioabsorbable material such as polyglycolic acid and materials with similar properties. Another method is to laser cut the frame out of a metal tube, such as stainless steel or nitinol. Still yet another method is to spot weld together, or otherwise attach, a series of separate struts that become the sides of a closed frame. In further alternative embodiments, the frame can be left with one or more open gaps that are bridged by the material stretched over the remainder of the frame. The frame can also be formed integrally with the covering, typically as a thickened or strengthened edge portion that gives the device sufficient rigidity to allow it to assume the deployed configuration in the vessel. To prevent the frame from radially expanding within the vessel beyond the point which would be considered safe or desirable, the device can be formed into the serpentine configuration and a circumferentially constraining mechanism, such as a tether, strut, sleeve, etc., placed around the device, or built into the frame, to expand or unfold during deployment of the device to limit its expansion to a given diameter, such as that which is slightly larger than the vessel into which it is placed to allow anchoring, but not permit the device to exert to great a force on the vessel wall.

Please amend the paragraph beginning on page 6, line 22 as follows:

In still another aspect of the present invention, a covering, which can be a flexible synthetic material such as DACRON polyester (trademark of E.I. Dupont de Nemours and Co.), or expanded polytetrafluorethylene (ePTFE), or a natural or collagen-based material, such as an allographic tissue (such as valvular material) or a xenographic implant (such as SIS), can be attached to the device with sutures or other means to partially, completely, or selectively restrict fluid flow. When the covering extends over the entire aperture of the frame, the frame formed into the

second configuration functions as a vascular occlusion device that once deployed, is capable of almost immediately occluding an artery. An artificial valve, such as that used in the lower legs and feet to correct incompetent veins, can be made by covering half of the frame aperture with a triangular piece of material. The artificial valve traps retrograde blood flow and seals the lumen, while normal blood flow is permitted to travel through the device. In related embodiments, the device can be used to form a stent graft for repairing damaged or diseased vessels. In a first stent graft embodiment, a pair of covered frames or stent adaptors are used to secure a tubular graft prosthesis at either end and seal the vessel. Each stent adaptor has an opening through which the graft prosthesis is placed and an elongated barb is attached to both frames. In another stent graft embodiment, one or more frames in the second configuration are used inside a sleeve to secure the device to a vessel wall.

Please amend the paragraph beginning on page 7, line 18 as follows:

FIGs. 3-3B depict a top view and enlarged, partial cross-sectional views of a second exemplary embodiment of the present invention;

Please amend the paragraph beginning on page 9, line 9 as follows:

FIG. 33 depicts an enlarged view of a portion of a delivery system for deploying an embodiment of the present invention;

Please amend the paragraph beginning on page 9, line 27 as follows:

FIG. 43 depicts a pictorial view of a frame embodiment formed into a deployed configuration;

Please amend the paragraph beginning on page 10, line 5 as follows:

FIG. 46 depicts a cross-sectional view of a second embodiment of valve having a unitarily formed frame and covering;

Please amend the paragraph beginning on page 10, line 9 as follows:

FIGs. 48-49 depict pictorial views of intraluminal valve embodiments that include a circumferentially constraining mechanism; and

Please amend the paragraph beginning on page 10, line 13 as follows:

The invention is further illustrated by the accompanying pictorial embodiments, which in no way should be construed as further limiting. The present invention specifically contemplates other embodiments not illustrated but intended to be included in the appended claims. FIGs. 1-11,18-19 are directed to a basic stent frame; FIGs. 12-14 are directed to a single-leaflet valve; FIGs. 15-16 are directed to an occluder (or filter); FIGs. 17 and 32 are directed to a stent adaptor for a stent graft, FIGs. 20-27, 35-40, 42-50 are directed to a multi-leaf valve; and FIGs. 28-31 are directed to a constrained frame which can be used to form any of the other embodiments.

Please amend the paragraph beginning on page 12, line 15 as follows:

The device 10 depicted in FIG. 1 is shown in its first configuration 35 whereby all four interconnections or bends 20,21,22,23 and each of the sides 13 generally lie within a single flat plane. To resiliently reshape the device 10 into a second configuration 36, shown in FIG. 2, the frame 11 of FIG. 1 is folded twice, first along one diagonal axis 94 with opposite bends 20 and 21 being brought into closer proximity, followed by opposite bends 22 and 23 being folded together and brought into closer proximity in the opposite direction. The second configuration 36, depicted in FIG. 2, has two opposite bends 20,21 oriented at the first end 68 of the device 10, while the other opposite bends 22,23 are oriented at the second end 69 of the device 10 and rotated approximately 90° with respect to bends 20 and 21 when viewed in cross-section. The medical device in the second configuration 36 can be used as a stent 44 to maintain an open lumen 34 in a vessel 33, such as a vein, artery, or duct. The bending stresses introduced to the frame 11 by the

first and second folds required to form the device 10 into the second configuration 36, apply force radially outward against the vessel wall 70 to hold the device 10 in place and prevent vessel closure. Absent any significant plastic deformation occurring during folding and deployment, the device in the second configuration 36 when not with the vessel or other constraining means, will at least partially return to the first configuration 35, although some deformation can occur as depicted in FIG. 34, depending on the material used. It is possible to plastically form the stent into this configuration which represents an intermediate condition between the first configuration (which it also can obtain) and the second configuration. It is also possible to plastically deform the device 10 into the second configuration 36, such that it does not unfold when restraint is removed. This might be particularly desired if the device is made from nitinol or a superelastic alloy.

Please amend the paragraph beginning on page 13, line 27 as follows:

A second embodiment of the present invention is depicted in FIG. 3 wherein one or more barbs 16 are included to anchor the device 10 following deployment. As understood, a barb can be a wire, hook, or any structure attached to the frame and so configured as to be able to anchor the device 10 within a lumen. The illustrative embodiment includes a first barb 16 with up to three other barbs 17,71,72, indicated in dashed lines, representing alternative embodiments. As depicted in FIG. 3A, the barb combination 38 that comprises barbs 17 and 18, each barb is an extension of the single piece 59 of material of the frame 11 beyond the closed circumference 59. The attachment cannula 15 secures and closes the single piece 59 of material into the frame 11 as previously described, while the first and second ends 60,61 thereof, extend from the cannula 15, running generally parallel with the side 13 of the frame 11 from which they extend, each preferably terminating around or slightly beyond respective interconnections or bends 20,23. To facilitate anchoring, the distal end 19 of the barb 17 in the illustrative embodiment contains a bend or hook.

Please amend the paragraph beginning on page 13, line 27 as follows:

Optionally, the tip of the distal end 19 can be ground to a sharpened point for better tissue penetration. To add a third and fourth barb as shown, a double ended barb 39 comprising barbs 71 and 72 is attached to the opposite side 13 as defined by bends 21 and 22. Unlike barb combination 38, the double barb 39, as shown in FIG. 3B, comprises a piece of wire, usually the length of barb combination 38, that is separate from the single piece 59 comprising the main frame 11. It is secured to the frame by attachment mechanism 15 using the methods described for FIG. 1. FIG. 4 depicts barb 17 (and 18) engaging the vessel wall 70 while the device 10 is in the second, deployed configuration 36. While this embodiment describes up to a four barb system, more than four can be used.

Please amend the paragraph beginning on page 14, line 26 as follows:

FIG. 7 depicts a top view of a third embodiment of the present invention in the first configuration 35 that includes a plurality of frames 11 attached in series. In the illustrative embodiment, a first frame 30 and second frame 31 are attached by a barb 16 that is secured to each frame by their respective attachment mechanisms 15. The barb 16 can be a double-ended barb 39 as shown in FIGs. 3 and 3B that is separate from the single pieces 59 comprising frames 30 and 31, or the barb may represent a long extended end of the one of the single pieces 59 as shown in FIG. 3A. Further frames, such as third frame 32 shown in dashed lines, can be added by merely extending the length of the barb 16. FIG. 8 depicts a side view of the embodiment of FIG. 7 in the second configuration 36 as deployed in a vessel 33.

Please amend the paragraph beginning on page 15, line 19 as follows:

FIG. 15 depicts a top view of a fifth embodiment of the present invention in the first configuration 35, whereby there is a full covering 57 that generally covers the entire aperture 56 of the frame 11. When the device 10 is formed into the

second configuration 36, as depicted in FIG. 16, it becomes useful as an occlusion device 51 to occlude a duct or vessel, close a shunt, repair a defect, or other application where complete or substantially complete prevention of flow is desired. As an intravascular device, studies in swine have shown occlusion to occur almost immediately when deployed in an artery or the aorta with autopsy specimens showing that thrombus and fibrin had filled the space around the device. The design of the present invention permits it to be used successfully in large vessels such as the aorta. Generally, the occlusion device should have side 13 lengths that are at least around 50% or larger than the vessel diameter in which they are to be implanted.

Please amend the paragraph beginning on page 16, line 24 as follows:

FIGs. 17-18 depict two embodiments of the present invention in which the device 10 functions as a stent graft 75 to repair a damaged or diseased vessel, such as due to formation of an aneurysm. FIG. 17 shows a stent graft 75 having a tubular graft prosthesis 54 that is held in place by a pair of frames 11 that function as stent adaptors 52,53. Each stent adaptor 52,53 has a covering attached to each of the frame sides 13 which includes a central opening 55 through which the graft prosthesis 54 is placed and held in place by friction or attachment to prevent migration. One method of preventing migration is placement of a stent adaptor 52,53 according to the present invention at each end and suturing the graft prosthesis 54 to the covering of the stent adaptors 52,53. The stent adaptors 52,53 provide a means to seal blood flow while centering the graft prosthesis in the vessel. A long double-ended barb 39 connects to each stent adaptor 52,53 and assists to further anchor the stent graft 75. In the embodiment depicted in FIG. 18, the covering 45 comprises an outer sleeve 64 that is held in place by first and second frames 30,31 that function as stents 44 to hold and seal the sleeve 64 against a vessel wall and maintain an open passageway 65. In the illustrative embodiment, the stents 44 are secured to the graft sleeve 64 by sutures 50 that are optionally anchored to the coils 14 of the bends 12. If the

embodiment of FIG. 18 is used in smaller vessels, a single frame 11 can be used at each end of the stent graft 75. Another stent graft 75 embodiment is depicted in FIG. 32 for repairing a vessel defect 97, such as an aneurysm in a bifurcated vessel. The stent adaptor 52 of the present invention is placed in the common vessel 96 such as the abdominal aorta. Two tubular grafts 54 are secured within an aperture 55 in the covering 45 of the frame 11 by one or more internal stent adapters 102, or another type of self-expanding stent, that bias the opening of the grafts 54 against the surrounding covering 45 to provide an adequate seal. Each leg 98,99 of the stent graft prosthesis 75 traverses the vessel defect 97 and feeds into its respective vessel branch 100,101 such as the right and left common iliac arteries. As with the embodiment of FIG. 17, a second stent adapter 53 can be used to anchor the other end of the tubular graft 54 in each vessel branch 100,101.

Please amend the paragraph beginning on page 17, line 28 as follows:

FIGs. 20-27 and 35-41 depict embodiments of present inventions in which the device 10 comprises an implantable valve having multiple leaflets 25 that act together to regulate and augment the flow of fluid through a duct or vessel 33, or within the heart to treat patients with damaged or diseased heart valves. The covering 45 of each of these embodiments includes one or a series of partial coverings 58 that form the leaflets 25 of the valve. As with the other embodiments, the covering 45 may comprise a biomaterial or a synthetic material. While DACRON, expanded polytetrafluoroethylene (ePTFE), or other synthetic biocompatible materials can be used to fabricate the covering 45, a naturally occurring biomaterial, such as collagen, is highly desirable, particularly a specially derived collagen material known as an extracellular matrix (ECM), such as small intestinal submucosa (SIS). Besides SIS, examples of ECM's include pericardium, stomach submucosa, liver basement membrane, urinary bladder submucosa, tissue mucosa, and dura mater. SIS is particularly useful, and can be made in the fashion described in Badylak et al., US Patent 4,902,508; Intestinal Collagen Layer described in US Patent 5,733,337 to Carr and in 17

Nature Biotechnology 1083 (Nov. 1999); Cook et al., WIPO Publication WO 98/22158, dated 28 May 1998, which is the published application of PCT/US97/14855. Irrespective of the origin of the valve material (synthetic versus naturally occurring), the valve material can be made thicker by making multilaminate constructs, for example SIS constructs as described in US Patents 5,968,096; 5,955,110; 5,885,619; and 5,711,969. Animal data show that the SIS used in venous valves of the present invention became replaced by native tissue in as little as a month's time. In addition to xenogenic biomaterials, such as SIS, autologous tissue can be harvested as well, for use in forming the leaflets of the valve. Additionally Elastin or Elastin Like Polypetides (ELPs) and the like offer potential as a material to fabricate the covering or frame to form a device with exceptional biocompatibility. Another alternative would be to use allografts such as harvested native valve tissue. Such tissue is commercially available in a cryopreserved state.

Please amend the paragraph beginning on page 19, line 23 as follows:

Typically, when used as a valve to correct venous insufficiency in the lower extremities, the valve 43 *in situ* comprises a plurality of bends 12 of the frame, that provide the majority of the outward radial force that helps anchor the device to vessel wall 70, as depicted in FIGs. 22-27. When deployed, the frame assumes the undulating or serpentine configuration characteristic of the invention with a first series of bends 115 of the first or proximal end alternating with a second series of bends 116 of the second or distal end, with the second or distal bends 116 being located at the bottom of the valve distal to the heart and the first or proximal bends 115 being located at the top of the valve proximal to the heart. It should be understood that the valve can assume other orientations, depending on the particular clinical use, and thus, any directional labels used herein ('distal', 'top', etc.) are merely for reference purposes. The leaflet 25, which generally covers the valve leg 113 and therefore, assumes the same roughly triangular 'U' or 'V' shape of that portion of the frame 11 perimeter, includes a resilient arcuate

outer edge 112 that conforms to and/or seals with the contours of the vessel wall 70, and an inner edge 111 that traverses the vessel lumen 34. The central portion or body 156 of the leaflet 25 extends inward from the vessel wall 70 and outer edge 112 in an oblique direction toward the first end 68 of the valve 43 where it terminates at the inner edge 111 thereof. The valve leaflets that come in contact with the vessel wall can also be arcuate as the supporting frame to better conform to and seal with the vessel wall. The leaflets 25 assume a curvilinear shape when in the deployed configuration 36. The portion of the body 156 proximate the inner edge 111 is sufficiently flexible such that is can move in and out of contact with the inner edge 111 of the opposite or other leaflets 25; however, the remainder of the body 156, particular that near the outer edge 112 or second end 69 of the device 10, can be made less flexible or even rigid in some instances, essentially functioning more for support, similar to the function of the frame 11, rather than to cooperate with other leaflet(s) 25.

Please amend the paragraph beginning on page 20, line 24 as follows:

FIGs. 20-27 depict the present invention as an implantable, intraluminal, vascular device adapted for use as an implantable multi-leaflet valve 43 including a stent 44 or frame 11 with at least a partial covering 58. The covering comprises a first and a second valve leaflets 78,79 that at least partially seal the aperture 56 within the frame 11 while the valve 43 is in the deployed configuration 36, and form the opening 117 or valve orifice which regulates the flow of fluid 46,47 through the valve. FIG. 20 shows the device 10 in the first, generally planar configuration 35 where the frame 11 is generally rectangular, or in particular, square in shape. The partial covering 58 forming the leaflets 78,79 generally extends across the entire frame 11 with the aperture 56 comprising a slit 108 that extends across the first axis 94 of the frame 11, the first axis being defined as traversing diagonally opposite bends (22 and 23 in this example) that are in line with the valve orifice 117 that forms the valve 43. The covering 45 is therefore divided into at least first and second portions (making it a partial covering 58)

which define the first and second valve leaflets 78,79. To form the leaflets 78,79, a complete covering 45 can be slit open along the axis after it is affixed to the frame, or at least first and second adjacent triangular portions (partial coverings 58) can be separately attached, eliminating the need for mechanically forming a slit 108. In the embodiment of FIG. 20, the slit 108 is made in the covering 45 such that the slit terminates a few millimeters from each of the corner bends 22,23, creating a pair of corner gaps 155, thereby eliminating two of the most likely sources of leakage around the valve 43. In the illustrative embodiments, the outer edge 112 of the partial covering 58 that comprises the leaflet 25 is stretched over the frame 11 comprising the valve leg 113, and is sutured or otherwise attached as disclosed herein. The leaflet 25 is secured in place such that the material is fairly taut, such that when the valve 43 is situated in the vessel 33 and its diameter constrained to be slightly less than the valve width 146, the leaflet 25 assumes a relatively loose configuration that gives it the ability to flex and invert its shape, depending on the direction of fluid flow. The inner edge 111 of the leaflet 25 is generally free and unattached to the frame and generally extends between the bends 22 and 23 (the bends 115 of the first end) of the valve leg 113. The inner edge 111 may be reinforced by some means, such as additional material or thin wire, that still would allow it to be sufficiently pliable to be able to seal against another leaflet 25 when retrograde flow 47 forces the leaflets 78,79 together. The leaflet 25 is sized and shaped such that the inner edge 111 of one leaflet 78 can meet or overlap with the inner edge 111 of the opposing leaflet 79 (or leaflets, e.g., 119,120), except when degree of normal, positive flow 46 is sufficient to force the leaflets 25 open to permit fluid passage therethrough.

Please amend the paragraph beginning on page 22, line 7 as follows:

The embodiments of FIGs. 21-27 are configured into an elongated diamond shape 153 in the planar configuration 35 with the distance between the two bends 22,23 aligned with the valve orifice 117 and first axis 94 being less than the distance between bends 20 and 21 along the second, perpendicular axis 95. This

diamond configuration 153 can be accomplished by forming the frame 11 into that particular shape, or constraining a square frame into a diamond shape 153, which will be discussed later. By configuring the valve 43 into the diamond shape 153, the valve legs 127,128 become more elongated in shape, which can help add stability when positioning the device 10 during deployment, providing more surface area to receive retrograde flow, and more closely mimicking a natural venous valve. In the deployed configuration 36 of the embodiment of FIG. 21, which is shown in FIGs. 22-25, the valve leaflets 78,79 are forced apart by the normal pulsatile blood flow 46 (FIGs. 22,24). The respective valve leaflets 78,79 naturally move back into closer proximity to each other following the pulse of blood. Retrograde blood flow 47 forces the valve leaflets 78,79 against one another, as depicted in FIGs. 23 and 25 thereby closing off the lumen 34 of the vessel 33 and the valve orifice 117.

Please amend the paragraph beginning on page 23, line 14 as follows:

FIGs. 26-26A depict one method of affixing a covering 45 comprising a biomaterial, such as SIS, to the frame 11 which has been constrained using a temporary constraining mechanism 121, such as a suture, to achieve the desired frame configuration. As shown in FIG. 26, the covering 45 is cut larger than the frame 11 such that there is an overhang 80 of material therearound, e.g., 5-10 mm. The frame 11 is centered over the covering 45 and the overhang 80 is then folded over from one long side 142, with the other long side 143 subsequently being folded over the first. As shown in FIG. 26A, the covering 45 is sutured to the frame along one side 142, typically using forceps 158 and needle, thereby enclosing the frame 11 and the coiled eyelet 14 with the overhang 80 along side 142. The covering 45 is sutured to the frame with resorbable or non-resorbable sutures 50 or some other suitable method of attaching two layers of biomaterials can be used. In the case of SIS, a single ply sheet, usually about 0.1 mm thick, is used in the hydrated condition. In the illustrative embodiments, 7-0 Prolene suture is used, forming a knot at one bend (e.g., bend 20), then continuing to the

next bend (e.g., 22) with a running suture 50, penetrating the layers of SIS around the frame at about 1-2 mm intervals with loops formed to hold the suture 50 in place. When the next coil turn 14 is reached, several knots are formed therethrough, and the running suture 50 continues to the next coil turn 14. If barbs are present, such as shown in the embodiment of FIG. 21, the suture 50 is kept inside of the barbs 16 located about each coil turn 14. In the illustrative example, the covering 45 is affixed to the frame 11 such that one side of the overhang 80 is not sutured over the other side in order to maintain the free edge of the overhang 80, although the alternative condition would be an acceptable embodiment. Alternative attachment methods include, but are not limited to, use of a biological adhesive, a cross-linking agent, heat welding, crimping, and pressure welding. For synthetic coverings, other similar methods of joining or attaching materials are available which are known in the medical arts. The covering 45, whether made from a biomaterial or synthetic material, can be altered in ways that improve its function, for example, by applying a coating of pharmacologically active materials such as heparin or cytokines, providing a thin external cellular layer, e.g., endothelial cells, or adding a hydrophilic material or other treatment to change the surface properties.

Please amend the paragraph beginning on page 25, line 5 as follows:

Referring now to FIGs. 28-31, the frame 11 used to form the valve 43 embodiments, e.g., FIGs. 20-27, that are placed in the legs or other deep veins as replacement for incompetent venous valves, is sized according to the size of the target vessel. For example, a typical venous valve might be made of .0075" 304 stainless steel mandril wire with an attachment mechanism 15 comprising 23 to 24 gauge thin-wall stainless steel cannula or other tubing. Larger wire (e.g., 0.01") and attachment cannula 15 are typically used for valves 43 of the larger diameter (greater than 15 mm). Selection of the attachment cannula 15 depends on competing factors. For example, use of larger gauge attachment cannula 15 results in a slightly increased device 10 profile, yet it includes additional room for

flux when the attachment mechanism 15 is soldered over the continuous wire 59 comprising the frame 11. FIG. 30 best depicts an uncovered frame 11 used to form a venous valve 43, wherein the length of the sides 13 typically ranges from about 15 to 25 mm. For larger frames, heavier gauge wire is typically used. For example, 25 mm frames might use 0.01" wire, with larger diameter embodiments such as stent occluders used for femoral bypass or stent adaptors, such as shown in FIGs. 17 and 32, requiring an even heavier gauge. The appropriate gauge or thickness of the frame wire also depends on the type of alloy or material used. As previously disclosed, the frame is typically formed in a generally flat configuration and then manipulated into its characteristic serpentine configuration and loaded into a delivery system. Therefore, the frame usually will tend to reassume the first or generally flat configuration if the restraint of the delivery system or vessel is removed. Deformation of the frame 11 can occur after it has been manipulated into the second configuration, however, such that it no longer will lie completely flat, as depicted in FIG. 34. This angle of deformation 129, which varies depending on the frame thickness and material used, generally does not compromise the function of the device 10, which can be reconfigured into the serpentine configuration (the second, deployed configuration) without loss of function.

Please amend the paragraph beginning on page 26, line 21 as follows:

The illustrative embodiments of FIGs. 41-41A and 43 include integral barbs 124 that extend from the frame 11, which being formed as a closed frame, does not have free ends 60,61 that can be used to serve as barbs 16 as depicted in FIG. 3 and other embodiments. FIGs. 41-41A depict a series of integral barbs 124 comprising V-shaped cuts 139 traversing the thickness of the flat metal frame 11, which are bent outward to form the barb 16. In the embodiment of FIG. 43, the integral barbs 124 are formed along with the frame 11 with two extending from the frame at either side of each bend 12. These integral barbs 124 can be designed into the mold if the frame 11 is formed out of a polymer material. The

number, arrangement, and configuration of the integral barbs 124 is generally not critical and can vary according to design preference and the clinical use of the device. The barbs 16 may or may not penetrate the covering, depending on their design and other factors, including the thickness and type of covering used.

Please amend the paragraph beginning on page 29, line 12 as follows:

FIGs. 21-31 depict various embodiments in which the bends 20,21,22,23 are placed in a resiliently tensioned or stressed state after being initially formed such that the bends were not under tension. The term 'tension', as used herein, is meant to describe generally a force applied to a resilient material or structure against the natural tendency of the material or structure, whether or not the force is in fact tensile, compressive, or torsional. Further incremental forces applied will generally encounter greater resistance than would otherwise be exhibited by the material or structure, such as a compression spring, which exerts a force (resilience) resisting compression proportional to the distance the spring has already been compressed. The addition of tension to one or more bends 12 of the device frame 11 can alter the properties of the frame 11 and result in improved sealing characteristics or the ability of the device 10 to impinge upon the vessel wall 70 to prevent migration or shifting. In the illustrative embodiments, the coil turn 14 is formed as previously disclosed whereby each bend 12 is in a untensioned state with the adjacent sides 13 having an initial angle after formation of the bend 12. For example, in the embodiment of FIG. 20, the initial angle 109 after the bends are formed and the final angle 110 after the frame 11 is assembled are both approximately 90°. Therefore, the bends 12 of the embodiment of FIG. 20 are not placed under any significant degree of tension. In the embodiments of FIGs. 21-31, the frame is restrained to permanently place the bends 12 under tension such that the angle between the sides 122,123 adjacent to the bend 12 is increased or decreased by some method of manipulation to produce a resiliently tensioned bend 118 (FIGs. 26 and 29) having a final angle 110 different than the initial angle 109 (e.g., FIG. 28).

Please amend the paragraph beginning on page 30, line 9 as follows:

Referring particularly to FIGs. 21-28, the covering 45 (including a full or a partial covering 58) can be attached to the frame 11 of the valve 43 or other embodiment of the present invention, to constrain a generally untensioned square frame 11 (such as in FIG. 1) and subsequently form an altered shape 82, such as a diamond 153, in which the distance between bends 20 and 21 is lengthened and the distance between bends 22 and 23 is shortened. By way of example, and using FIG. 21 as reference, the angle 110 measured between the adjacent sides 13 from bends 20 and 21 might decrease to 70-80° with increases in the corresponding angles 161 measured at bends 22 and 23 to 100-110°. This manipulation of the frame 11 shape serves to add tension in each of the bends, which allows better positioning of the device 10 against the vessel wall 70 while in the deployed configuration, as shown in FIGs. 22-25. Additionally, constraining the frame 11 along the first axis 94 of the slit 108 allows that distance 146 to be adjusted to provide the optimum size for the vessel 33 into which the valve 43 is to be implanted. Assuming a resilient frame 11 is being used that makes the valve 43 radially expandable, it would normally be preferential to slightly oversize the valve 43 along at the width 146 of the frame 11 (along first axis 94) when the valve 43 is in the generally flattened configuration 35, thereby causing the leaflets 78,79 to relax slightly when the valve 43 is in the deployed configuration 36 and being constrained slightly by the vessel 33. The proper length of the constrained frame 11 as measured diagonally between bends 22 and 23 is calculated such that the leaflets 78,79 open by an effective amount in the presence of blood flow 46 that most closely mimics that found in a normal functioning valve.

Please amend the paragraph beginning on page 31, line 5 as follows:

Dog studies by Karino and Motomiya (*Thrombosis Research* 36: 245-257) have demonstrated that there is about a 60 to 70% constriction of blood flow through the natural valve. In the valve 43 of the present invention, the leaflets 25 should ideally span about 30-60% of the vessel 33 diameter across. If it is much

less than 30%, blood flow 46 may be impeded to an unacceptable degree, while if the leaflets 78,79 are allowed to fully open, they can adhere to the vessel wall 70 and therefore, not close properly in the presence of retrograde flow 47. The frame 11 can be formed or constrained such that the distance 146 between points 22,23 lies between πr, which would allow the valve to open to the full extent that the vessel allows, and 2r in which the valve 43 is stretched tight across the frame 11 and is very limited in the amount of blood that will allow to pass through. To give the leaflets the flexibility and compliance to open to permit flow and then close to seal against backflow, the slit axis distance 146 of the valve 43 should be oversized with respect to the diameter of the vessel into which it is to be placed. Constraining the valve 43 along the first axis 94 such that it sized a few mm larger than the lower extreme (2r) or a few mm larger than the upper extreme (πr), not only allows the leaflets to function in a more optimal manner, but also allows the valve 43 to safely and effectively impinge on the vessel wall to seal and reduce the possibility of migration. The ideal amount of oversize is largely dependent on the size and diameter of the frame 11 prior to resizing. FIG. 49 depicts a schematic top view of the valve of FIG. 22 showing the length 147 of the orifice, the width 148 of the orifice, the portion 154 of the vessel occluded by a leaflet 25, and the corner gaps 155 that exist between each lateral edge 156 of the valve orifice 117 and the outer edge 112 of the leaflet 25 (or the frame 11). The following formula can be utilized to approximate the elliptic circumference (C) of the valve orifice 117, where a=one half the length 147 of the orifice, and b=one half the width 148 of the orifice 117:

Please amend the paragraph beginning on page 32, line 6 as follows:

Assuming that we wish to size the valve 43 to produce an orifice 117 that opens approximately 30-60% of the vessel lumen 34 (with the occluded portions 154 comprising 40-70% of the same), the preceding formula can be used to determine the amount of oversize that produces the desired characteristics. The amount of oversize (valve width 146 in the flat configuration minus the diameter

of the vessel lumen 34) would generally range from 1-2 mm for smaller valves (those placed in 8-9 mm vessels) up to 3-4 mm for valves intended for larger vessels (17-21 mm). For example, a valve intended for a 14 mm vessel should ideally have a 2-3 mm oversize if the range of 30-60% opening is to be maintained. If the frame 11 of a valve 43 having 20 mm sides is constrained such that the distance between bends 22 and 23 is adjusted to approximately 16 mm, the valve 43 opens approximately 43%, which is well within the most desired range. If constrained to 17 mm, the valve 43 is able to open up to approximately 55% of the vessel diameter. In contrast, oversizing the valve 43 by 6 mm, produces a large orifice 117, 83% of which lies outside the target range, although it would certainly produce a valve 43 capable of opening and closing in response to fluid flow 46,47. To produce a valve 43 in which the valve width in the generally flattened configuration 35 is 17-18 mm, which would be a valve 43 sized to accommodate a 14-15 mm vessel, the 20 mm frame 11 should be constrained such that the distance between bends 22 and 23 is 15 mm prior to addition of the covering 45, if a compliant material such as SIS is used. As depicted in FIG. 26, the frame 11 is constrained across the first axis 94 using a temporary constraining mechanism 121, such as by tying a suture through the coil turns 14 of bends 22 and 23 to pull them toward one another until a distance of 15 mm is reached. After the covering 45 has been attached, such as by the method previously disclosed, the temporary constraining suture 121 is cut, which results in a slight expansion in the width of the frame 11 as the SIS stretches under the tension of the constrained frame, resulting in the desired final width of 17-18 mm. The amount of expansion varies with the compliance of the particular covering 45 as well as with the resiliency of the frame 11. Although the desired final width 146 of the constrained frame 11 can result from a relatively wide range of initial frame 11 sizes, depending on how much the frame is constrained, generally, larger sized frames (e.g., sides measuring about 25 mm) are most suitable for larger vessels (e.g., 16-21 mm in diameter), while smaller frames (e.g., 15 mm) are most suitable for smaller diameter vessels (e.g., 8-9 mm). While this range represents the most common sizes used for correcting venous valve insufficiency in the lower legs, valves 43

of the present invention can be made in a much larger range of sizes to treat veins or other vessels elsewhere in the body.

Please amend the paragraph beginning on page 33, line 20 as follows:

FIGs. 28-31 depict another embodiment of the present invention in which an open frame 11, such as is depicted in FIG. 28, is assembled into a square frame (FIGs. 29-31) such the bends 12 are put under tension. The resiliently tensioned bends 118 in the assembled device (as shown in FIGs. 29-31) result from the initial angle 109 formed in wire frame 11 before being assembled into a closed circumference 62 (FIG. 28), being greater than the final angle 110. To form the embodiment of FIG. 1, for example, the wire is wrapped around a pin to form the coil turns 14 with the sides 13 generally lying about 90° with respect to one another. The attachment mechanism 15 then secures and closes the frame 11 to form the final square shape. In the embodiments of FIGs. 28-31, the first angle 109 is made approximately 150°, rather than 90°, which is the desired final angle 110. While the wire is not under stress after the bends 12 are initially formed, the bends 12 and sides 13 are stressed when the device 10 is constrained during assembly to form the four-sided, generally square shape. In particular reference to FIG. 30, the sides 122,123 adjacent to a resiliently tensioned bend 118 become somewhat deformed when the bend 12 is put under stress, generally assuming a bowed shape between the adjacent bends. By creating this 'rounded square' with tensioned or stressed bends 118, the sides 13 of the frame 11 are able to better conform to the rounded vessel wall 70 than would a side 13 that is initially straight prior to deployment. Additionally, by rounding the distal bends 116 of the valve legs 113, it may also reduce the potential for the valve legs 113 to cause trauma to the vessel 33 as they continue to exert force thereupon.

Please amend the paragraph beginning on page 36, line 8 as follows:

FIGs. 30-31 depict alternative methods of forming the frame 11 and attaching barbs thereto. In the embodiment shown in FIG. 30, multiple attachment

mechanisms 15,85 and 84,86 are utilized per side rather than a single cannula as shown in previous embodiments, such as FIG. 29. Rather than placing the attachment mechanisms 15 at the point 87 where the respective ends 60,61 of the wire frame 11 cross to form the square shape, two attachment mechanisms 15,85 are placed on either side of the cross point 87. Having an additional attachment mechanism 84,85,86 on a side 13 provides better fixation of the frame with little additional metal and helps prevent twisting of the frame 11. On the opposite side which contains the double ended barb 39, the double attachment mechanisms 84,86 arrangement provides a similar function. In the embodiment of FIG. 31, three attachment mechanisms 15,85,88 and 84,86,89, are used per side which provide better fixation of the frame 11 as well as serving as attachment points for including supplemental barbs 90,91,92,93 to provide a more secure anchoring of the device 10 to the vessel wall 70. The illustrative barbs 16 are typically configured such that they extend only a short distance (less than 1-2 mm) beyond the bends 12; however, the barbs 16 can be made virtually any practical length, such as extending them more than 1 cm beyond the bends 12 to aid in stabilizing the device 10 upon deployment such that it does not shift laterally and end up being cockeyed within the vessel. To assist in this function, the barbs can be shaped accordingly, rather than be limited to a substantially straight configuration.

Please amend the paragraph beginning on page 37, line 3 as follows:

The present invention is not limited to a two-leaflet valve 43 (or two-leg occluder or stent adaptor, etc.). FIGs. 35-40 depict multi-leaflet valves 43 having three or four valve legs 113 and leaflets 25. The addition of additional leaflets reduces the load produced by the fluid column upon each individual leaflet 25. This in turn, puts less stress upon the sutures or attachment points of the covering 45, thereby allowing the valve 43 to function under higher pressures than would otherwise be possible. For example, these valves 43 could prove advantageous for use on the arterial side, such as to augment pulmonary valves, or within the

heart itself, where pressures exerted on the leaflets can be significantly higher than those normally found on the venous side. FIG. 35 depicts a valve 43 which in the generally flattened configuration 35, has three legs 127,128,130 that lie approximately 120° with respect to one another. The respective leaflets are arranged such that the inner edges 111 thereof, define a triangular-shaped valve orifice 117. When the illustrative valve 43 is placed in the vessel 33 for which it has been properly sized, as depicted in FIG. 37, the leaflets 78,79,119 are able to close against one another to seal the valve. The concept of adding additional legs 113 to distribute the load over a larger number of attachment points 50 (e.g., sutures) and add positional stability to the device 10, can be applied to occluders and stent adaptors as well.

Please amend the paragraph beginning on page 38, line 25 as follows:

Delivery of the device 10 of the present invention can be accomplished in a variety of ways. One method, depicted in FIG. 33, involves the use of a delivery system 103 similar to that used to deliver embolization coils. The delivery system 103 comprises an outer member 105, such as a cannula or catheter, and a coaxial inner member 105 that includes a tethering tip 107, such as a notched cannula, adapted to receive a barb tip 104 extending from the frame 11. The tip 104 of the barb is configured such that it can positively engage with the tethering tip 107. This can be accomplished by adding a projection, such as a secondary barb, hook, spine, etc. to the tip 104, or otherwise enlarging the diameter thereof such that it can be releasably secured by the tethering tip 107 until deployment. The coaxial inner member 106 also includes an outer sheath 149 that retains and locks the barb tip 104 within the tethering tip 107 until it is advanced or retracted by manipulation of a proximal handle (not shown) to expose the notch 150 in the tethering tip, which releases the barb tip 104 and deploys the device 10. The device 10 is preloaded within the outer member 105. The coaxial inner member 106 and attached device 10 are then advanced together from the outer member 106 at the target site. Further manipulation of the proximal handle, advances the

tethering tip 107, which in this particular embodiment, includes a coiled spring 151, relative to the outer sheath 149. After the device 10 has been released from the tethering tip 107, the spring-activated handle is released and the outer sheath 149 slides back over the tethering tip 107. The coaxial inner member 106 is withdrawn into the outer member 105 and the entire delivery system 103 is removed from the patient. As shown in FIG. 33, the barb tip 104 extends just beyond the coil turn 14 of the frame 11 so as to have sufficient room to engage with the coaxial inner member 106. The barb tip 104 must be positioned to account for whether the device 10 is to be placed using a femoral approach or a superior approach.

Please amend the paragraph beginning on page 39, line 25 as follows:

The illustrative delivery system 103 represents only one of many possibilities. For example, the device 10 can be attached to a delivery device using screws, clips, magnets, or some other tethering mechanism, or can be deployed by applying electrical current, heat, or some other means to cause detachment with a carrying mechanism. As previously disclosed, rather than making the device 10 self-expanding, where it is deployed from some sort of constraining tubular device, it can be formed from a ductile material, mounted over a balloon or other inflatable or expandable delivery mechanism, and deployed by expanding the device in that manner.

EXPLANATION

Applicants have reason to believe that the page of drawings that includes FIGs. 26-26A may have been accidently omitted from the application as filed. Therefore, we have enclosed the formal drawings for the original missing sheet containing these two figures and ask that the examiner enter them into the case, if indeed the filed application does not already include this page. We suggest that the two figures do not represent new matter for three primary reasons. The two drawings represent the same two-leaflet valve embodiment depicted in FIGs. 21-

25 with only two well-known ancillary instruments, forceps 158 and scalpel 159, being the only referenced items or elements which are shown only in those particular figures, neither being part of the core invention. Therefore, the two figures, which help depict one exemplary method of attaching the covering to the frame, do not represent a new and additional embodiment that is not already depicted elsewhere. Secondly, the Detailed Specification, from page 23, line 14 to page 25, line 4, provides a complete and detailed description of everything which is shown in FIGs. 26-26A, such that the specification fully supports the drawings. Therefore, the drawings are not required to understand the described method of attaching the cover, nor do they depict steps or structure not adequately described in the specification. Thirdly, a skilled person in the medial device arts would readily understand the steps of attaching a covering to a frame, such as that described in the specification, and certainly would not require the drawings to practice the invention. FIGs. 26 and 26A are merely provided for the reader's convenience as a visual reference when reading that portion of the specification. For these reasons, Applicants respectfully request that the Examiner allow these two figures into the application, thereby maintaining the original file date of the application, and not consider them to be new matter.

The amendments to FIG. 21 and 21A are to add element numbers mentioned in the specification, but omitted from the respective drawings. FIG. 3 is being amended to conform with FIG. 3 of the parent case (Pat. No. 6,200,336).

Respectfully submitted,

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